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Think Aloud Videos and Assessment in an Introductory Economics Class for Undergraduate Students

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Abstract. This paper demonstrates the value of an innovative test preparation strategy, applied over multiple semesters to one principles of macroeconomics class. The professor makes a video of himself taking a copy of the test students are preparing for, talking aloud about how to think about the question and work through the solution. A natural experiment occurred one semester when the professor was unable to provide the think-aloud preparation video, but other, standard preparation materials were in place. It is demonstrated that students increase their scores on other questions in the same modules by an average of 7.6 percentage points with think-aloud videos. Think aloud interventions are shown to be an effective tool to enhance student content learning.

Educators have three main tasks: develop students' interest in learning class content, deliver content, and assess how well students have learned the content (Care et al., 2018). Faculty time and energy devoted to assessment is one of the most important elements regarding student learning. College instructors want to engage their students with the best learning conditions possible to improve content comprehension, including keeping students engaged between class sessions and at the assessment stage.

This paper presents a novel application of the Think Aloud strategy, traditionally used in reading and problem-solving disciplines, to the domain of economics test preparation. The innovative aspect lies in its integration into a flipped classroom model for economics, combined with formative assessment, which has not been extensively explored in higher education economics courses. Furthermore, this study leverages a natural experiment to assess the direct impact of Think Aloud (TA) videos on student performance, providing new insights into student engagement and content mastery in economics.

Introductory economics is considered a core course for many freshmen students at universities across the world (American Council of Trustees and Alumni, 2010). Since introductory economics is central to the curriculum of many universities and colleges, researchers have an interest in reviewing such courses' content offerings with student learning performance and opportunities in mind (Chen & Okediji, 2014; Happ et al., 2016; Ramos Salazar & Hayward, 2018). Baehler (2013) reported the most significant predictor of success for microeconomics students on the Test of Understanding College Economics, 4th edition (TUCE) (Walstad et al., 2007) was their "grade received in the principles of economics course" (p. iii).

Many strategies and techniques with introductory economics courses have been reviewed by researchers for their impact on engagement and content learning (Jones, 2014; Miners & Nantz, 2009; Shanklin & Ehlen, 2017). Discovering and presenting research-based strategies to improve student learning outcomes with introductory courses in economics could provide many students the means to grasp difficult concepts. For example, Miners and Nantz (2009) reported the use of transparent, open communication with students concerning course goals and the related activities required increased student engagement for learning economics content. "When students understood why we were doing particular sorts of exercises and activities, they responded by engaging in them more actively" (Miners & Nantz, 2009, p. 32). Providing active learning experiences for students with a communicated purpose that is clearly delineated has the potential of improving students' learning in introductory economics courses. New instructional experiences for students who struggle with college and economics course content, including the flipped classroom model, problem-based learning, and think alouds have been proven to significantly improve students' performance on average when compared to traditional means. However, these effects may be larger for better-prepared students and no one tool will be a panacea for all educational needs of a diverse student population (Abío, et al. 2019; Craft & Linask, 2019; Marcal, 2018). Wardoyo, et al. (2021) demonstrate the problem-based learning improves economics undergraduates' metacognition. Alcalá et al., (2018) highlight that formative assessment encourages metacognitive development by allowing students to self-check and reflect on their learning. In this study, TA videos functioned as formative

assessment tools, enabling students to monitor their thought processes and adjust their understanding during test preparation.

This paper examines the impact of an innovative test-preparation method. The professor records videos of himself taking a version of the tests and speaking aloud about how to think through the problems. It is shown that students are able to generalize the critical thinking, problem-based learning skills being modeled and perform better on the tests than when these videos are not available. The remainder of this section explains why thinking aloud and problem-based learning are effective tools for developing students' critical thinking skills and understanding economics at a deeper level.

Literature Review

Think Alouds

The innovative test preparation method developed in this paper builds on several strands of educational literature, including thinking aloud, critical thinking, and problem-based learning. TA cognitive modeling strategies have their origin in the reading discipline and have been employed in K-12 schools for many years (Davey, 1983; Smith, 2006). TA strategies may include a teacher or students sharing their thinking concerning a problem, topic, or process. Teachers use TA strategies to model appropriate research-based thinking processes that will engage critical thinking for evaluation and discussion (Bikowski & Casal, 2018; Ebner & Ehri, 2013; Ku & Ho, 2010). Higher education faculty have increasingly employed TA strategies to guide students' thinking while engaging with the content. For example, Pergams et al. (2018) concluded that "reading aloud" of college-level biology content should immediately be followed by "thinking aloud" of the same content; students read more and understood the content better. In higher education, the TA protocols have been used to evaluate individual learning or perceptions of learning (AlDahdouh, 2019; Latif, 2019).

[Think alouds] TAs are crucial for enhancing content learning and will have an international appeal because thinking is universal, and displaying the thinking for both faculty and students provides the starting place for discussions that are foundational for learning progress.

TAs are a form of formative assessment (see Barkley & Major, 2016 for an in-depth treatment of formative assessment). Formative assessment allows the instructor and students to determine the students' general learning needs, the content learning gaps, the misinterpretations of concepts, and more. Formative assessment is the checking-in on learning while learning is in progress. When college instructors model formative assessment, their students learn its importance and will more likely self-check their learning and the learning of peers in collaborative projects. Formative assessment is a natural communicative process and governs real-life situations involved with learning and the application of learning (Alcalá et al., 2018). By providing college students experiences using formative assessment found in the feedback provided by their professors and peers, college students experience critical thinking in the moments they self-check their learning or while modeling this behavior with peers (Alcalá et al., 2018; Weldmeskel & Michael, 2016).

Chen and Mathies (2016) argue that assessment is culturally based and must be flexible,

> A good assessment tool in one setting can be totally inadequate in another setting. Researchers and practitioners may be tempted to adopt or translate established assessment tools from another country or language, but doing so requires intimate knowledge of the cultural differences between the assessment's developer and adopter. (pp. 89-90)

TAs are crucial for enhancing content learning and will have an international appeal because thinking is universal, and displaying the thinking for both faculty and students provides the starting place for discussions that are foundational for learning progress. Further, having professors model the critical thinking processes aloud adapts the content to the specific context and culture of the learners.

TA protocols provide a communication medium to increase engaged learning discussion experiences among peers and with instructors by allowing critical thinking to be the main focus (Abas & Aziz, 2016; Latif, 2019). To the extent that "learning to think like an economist" is one of the primary goals of introductory economics courses, modeling that thinking in applications students are likely to actually encounter on the test will encourage students to develop those specific habits of critical thinking.

Critical Thinking, Problem-Based Learning, and Test Experience

Thinking aloud about real world problems that can be addressed with economic thinking helps students develop skills that can be useful to them in their future careers and lives. The goals of any active educational experience are centered around critical thinking (Junus et al., 2019). One framework for teaching critical thinking that is particularly well-suited to introductory economics and thinking aloud is the Problem-Based Learning (PBL) teaching model. Rather than relying on the regurgitation of definitions that students in the real world can easily google if they need them again, PBL challenges students to apply course content to interesting, real world questions. This makes it ideal for an introductory economics course, where so much of the material applies to current or recent events. To provide one example of how PBL was used in the Principles of Macroeconomics class understudy, following a unit on Keynesian and supply-side views of the effects of taxation, students were put into groups with an instruction to identify why the Kennedy and Reagan tax cuts of the 1960s and 1980s might have had different impacts on the US economy than the Bush and Obama tax cuts of the 2000s did. They think aloud together as a group and again as a class, with the instructor providing correction and additional information as needed. Students were likely to see a question on the following test that involved the same principles identified in this experience.

Nargundkar et al. (2014) reported a Guided PBL approach's linkage to improved critical thinking skills in a core business analysis course with significantly higher average (9% higher) achievement on the course's final exam results and indicated improved student motivation for learning. Zhou (2018) demonstrated PBL significantly improved university students' critical thinking skills in the areas of analysis and interpretation. PBL experiences that encourage and challenge students to use critical thinking skills during their active learning experiences and to have discussions or debate during and after their respective cooperative PBL experiences have proven to be beneficial for many university students (Jones & Cooke, 2006; Mumtaz & Latif, 2017; Nargundkar et al., 2014). With PBL, the learning process becomes the focus and not the end product. Hansen (2006) shared the pragmatic learning framework PBL offers students learning accounting content,

> In sum, PBL uses problems to introduce topics and to serve as a focal point for learning new material. Complex problems are used to motivate students to acquire, communicate, and integrate information. PBL can foster students to think critically and solve complex problems, find and use learning resources, work in teams, use effective communication skills, and become continual learners. (p. 223)

Research concerning effective test preparation in economics curriculum at the college level is limited. Vazquez and Chiang (2016) provided pre-lecture materials to students with no exposure to economics courses or content, and these students "scored higher on comprehension and retention" when compared to students who only had access to the textbooks. There is a clear need for deeper investigation into the effectiveness of TA strategies in economics classrooms; the present study is an attempt to fill that need.

Materials and Methods

This study was conducted at a mid-size public university in Texas, focusing on two large face-to-face sections of a Principles of Macroeconomics course taught in Fall 2015 and Spring 2016. The sections had 94 and 96 students respectively. Both sections were taught by the same professor. The course employed a partially flipped teaching method, where students watched lecture videos before class and engaged in interactive activities during class. Tests were administered via Blackboard on students' personal computers. The assessments' format used multiple-answer and numerical questions. Nearly two-thirds of incoming freshmen students are the first in their family to attend college. The Principles of Macroeconomics course is required for all business, agribusiness, and education preparation students and may be used to fulfill general education requirements.

The course is taught in a partially-flipped method. Students are typically assigned 15-30 minutes of lecture videos to watch in preparation for each class period, and that time is then recaptured in the classroom for more engaged instruction: debates, group work, experiments, and so forth.

Tests were administered in the classroom on students' personal computers via the Blackboard learning management system. Most questions were multiple answer style: questions had between one and eight correct

answers; students received partial credit for each correct answer they marked and lost credit for each incorrect answer they marked. For some questions, students typed in a numerical answer.

Each student answered 30 questions. To ensure the integrity of the test, each question was drawn randomly from pools of 3-17 questions, generating nearly 331 quintillion different possible tests. The order of answers was also randomized for each student. The professor proctored tests and monitored student behavior.

Among the materials provided to help students prepare for the midterm and cumulative final examinations were a set of videos. In these videos, the professor took a test drawn from the same pools the students would encounter, speaking aloud about his thought process—how to think about the question, what parts of the course were relevant to answering the question, and evaluating each of the potential answers. Students were also provided with written review notes, a class period where the professor had gone over the kinds of questions that would be on the test and worked practice problems, and a student instructor who held review sessions.

During a test preparation video, the professor models the thinking aloud process. After reading the question, the instructor pauses to verbally recall important information that is related to answering that question. That might include sketching a demand/supply graph, reviewing the differences between Classical and Keynesian thought as it relates to the question, or revisiting the definition of opportunity cost and an example from an earlier class activity. For a multiple choice or multiple answer question, the instructor then goes through each possibility, explaining why that particular answer is or is not correct by connecting it to the information just reviewed. Going through the questions in this thorough manner corrects misinterpretations, prevents biased or normative thinking by focusing on positive theory, and reinforces content learned earlier in the class.

There are several pedagogical advantages to providing this experience as a set of videos rather than only as a single review session. First, students are verbally encouraged to pause the video and try to answer it themselves so they can then check their understanding against the professor's explanation. This is formative assessment. Second, students can pause the video at any time and take as much time as they need to consider and process the content—or alternatively speed up the video for a faster review—to meet the needs of students with diverse abilities. Third, students can rewatch the videos multiple times. While the course learning management software used in this study did not permit the researchers to identify who watched which videos or when, the average video was watched 2-5 times per student in the class. This suggests both that students are deeply interested and engaged in using these videos and that the ability to rewatch the reviews is valuable to them.

The identifying variation for this study relies on an unanticipated natural experiment. These videos were typically produced fresh each semester as content and test timing varied. During the Fall semester 2015, the economics professor fell ill and was unable to produce videos for the second midterm before the test. The following semester, Spring 2016, the customary videos were available to students. Despite having review sessions and written review notes, average, pre-curve test scores were significantly lower in Fall 2015 than they had been on the first midterm for that class and lower than had ever been for the second midterm. This paper will compare the Fall 2015 second midterm results with the Spring 2016 results.

Unfortunately, there is an imperfect overlap in the tests between semesters. The only unit of the test that was the same in both semesters dealt with tax policy: one question on tax ethics, one on the U.S. tax system, and one on supply side economics. There were five identical questions in the tax ethics pool, five in the tax system pool, and four in the supply side pool, for a total of 14 questions that were the same both semesters. These are not the only questions in their respective pools but are the only ones that are the same both semesters.

Students in the Spring 2016 course also encountered similar questions on their final exam for the first time that the Fall 2015 students first attempted in their second midterm: three in the pool on the market for loanable funds, five numerical questions on the future value of retirement savings, ten questions on retirement plans, and six questions on the U.S. Social Security system that were the same in both semesters for a total of 24 additional questions. Again, these are not the only questions in their respective pools, but they are the only ones that are the same both semesters. In the following regressions, we will consider the tax module and the retirement module both separately and combined into one larger regression.

Because each question is observed more than once, the data set is panel data. Ordinary Least Squares regression would ignore the panel structure, treat the same question in two different semesters as if they were two completely different questions, and essentially assume that all questions had the same initial difficulty. Panel regressions such as the fixed-effects model and random-effects model assume instead that each question has a different initial difficulty but that this difficulty is constant across semesters. In the fixed-effects model, each question has an individual intercept (α_i below) that does not change between semesters. Ignoring this factor would lead to a biased

estimate of the impact of videos on student performance. In the random-effects model, each question has an individual error ($e_{it} + u_i$) that is constant across semesters, leading to heteroskedasticity if it is not corrected.

The dependent variable is the average score of the class on question *i* in semester *t* (S_{it}), controlling for whether that semester had think aloud videos (TA_{it}) the type of question (Numeric = 1 or Multiple Answer = 0), and whether that question in particular appeared in the test preparation Video in Spring 2016.

$$S_{it} = \alpha_i + \delta_1 TA_{it} + \delta_2 Video_{it} + \delta_3 Numeric_i + \epsilon_{it}$$

The primary null hypothesis of the study is that $\delta_1 = 0$, meaning that students will perform no better on questions when they have seen the professor review similar questions. If $\delta_1 > 0$, then there are positive spillover effects from the TA videos. Note that $\delta_3 > 0$ tells us only that questions students have already seen the professor solve were easier for them, which is not as useful or meaningful. It is the higher score on questions they did not see which suggests that TA videos are an effective means of helping students understand economic material.

Descriptive statistics for both sections are found in Table 1. All data are available from the authors by request. They show that both sections were demographically similar, though Fall semester had more freshmen and Spring had more juniors. Some upward drift is to be expected as 1) incoming business freshmen are often advised by faculty in the summer to take economics their first semester; 2) as students complete coursework, students advance from freshman to sophomore to junior. More meaningfully, videos had been available to students in both semesters for the first midterm and there was no observable difference in average student outcomes. Average pre-curve scores on the first midterm were 66.89% (standard deviation of 12.49) in Fall 2015 and 68.51 (standard deviation of 13.56) in Spring 2016. This adds reassurance that the two groups of students were ex ante similar.

Table 1

Descriptive Statistics

	Fall 2015	Spring 2016
N	94	103
Freshmen	31 (33.0%)	19 (18.4%)
Sophomore	28 (29.8%)	35 (34.0%)
Junior	28 (29.8%)	41 (39.8%)
Senior	6 (6.4%)	8 (7.8%)
Business major	71 (75.5%)	63 (61.2%)
Agriculture major	14 (14.9%)	24 (23.3%)
Other major	9 (9.6%) (3 nursing)	16 (15.5%) (5 education)
Female (approximate)	44 (46.8%)	48 (46.6%)
DFW rate	24.5%	25.2%

Source. Author calculation

Results and Discussion

The analysis used fixed-effects and random-effects models to account for the varying difficulty of questions. It revealed that TA videos led to a 7.6 percentage point improvement in comprehension, translating to a 16% increase

in performance. The videos aided students in understanding and retaining content better, practicing effectively, and possibly reducing test anxiety. Further research is needed to identify the pathways that impact student learning and their effectiveness across different disciplines.

The data in Table 2 show a consistent pattern whether we consider the tax module (columns 1-3) and retirement modules (columns 4-6) separately or combine them (columns 7-9). The actual number of observations using pooled data is the number of questions (n) times how frequently each question is seen (t), so in this case there are twice as many observations as there are questions. The main variable of interest is TA, which shows that in those semesters with TA videos, students performed better on average than when the TA videos were not available. The coefficient for Video demonstrates only that students perform better on questions they have already seen and the coefficient for Numeric shows that students may perform slightly better on the mathematical questions than the conceptual questions.

Table 2

Results

	Tax Module $N = 14$, $t = 2$			Retirement Module $N = 24$, $t = 2$			Both Modules $N = 38$, $t = 2$		
	Pooled	Fixed	Rand.	Pooled	Fixed	Rand.	Pooled	Fixed	Rand.
Semester	0.094 (0.068)	0.080 (0.032)**	0.083 (0.031)***	0.056 (0.051)	0.079 (0.029)**	0.073 (0.029)**	0.067 (0.041)	0.080 (0.023)***	0.076 (0.023)***
Video	0.200 (0.109)*	0.265 (0.069)***	0.253 (0.065)***	0.130 (0.065)*	0.069 (0.048)	0.085 (0.046)	0.159 (0.057)***	0.118 (0.041)***	0.129 (0.039)***
Numeric				0.087 (0.047)*		0.087 (0.063)	0.129 (0.046)***		0.131 (0.061)**
R^2	.243	.927		.227	.895		.269	.902	
F-test p-value		0.0003			0.0000			0.0000	
B-P p-value			0.003			0.0005			0.0000
Hausman p-value			0.526			0.329			0.457

Source. Authors' calculation. Coefficients shown with standard errors in parentheses. *** = significant at 1% level, ** = significant at 5% level, * = significant at 10% level. Note that because a question is constantly numeric or multiple answer in each semester, this variable cannot be used in the fixed effects model. The "F-test p-value" tests the null hypothesis that each question has the same difficulty (i.e. – compares fixed vs. pooled). The Breusch-Pagan p-value tests the null hypothesis that there is heteroskedasticity present (i.e. – compares random vs. pooled). The Hausman p-value tests the null hypothesis that the errors are correlated with the regressors (i.e. – compares fixed vs. random)

In the pooled model (columns 1, 4, 7), which is identical to Ordinary Least Squares and assumes that all questions are equally difficult, the videos help students understand (or remember the answers to) that particular question only and have no spillover effects to other questions. Even that modest conclusion is only significant at the 10% level.

However, once the difficulty level of each question is controlled for in either a fixed-effects or random-effects model, the videos are shown to succeed in generating positive spillover effects. Students perform better on questions they have not seen when provided with TA videos. The null hypothesis that all questions have a similar constant term

(and therefore the pooled model is correct) is soundly rejected every time, as is the assumption that there is no heteroskedasticity, favoring either the fixed-effects or random-effects model respectively. The Hausman test fails to reject the null that the unique errors are correlated with the regressors, favoring the random-effects model over the fixed-effects model. Given that each question is seen only twice, this is not unexpected.

Using our preferred specification that combines all available data with a random-effects model, we see that the TA videos improve student content comprehension by about 7.6 percentage points. Given that the unadjusted test average for these questions was around 47%, this represents nearly a 16% improvement in student performance. No matter whether we are considering only the tax questions that students saw at the same point in the semester, only the retirement questions (which one section saw on a test one month earlier than the other section), or both together, student performance on the exams improves by 7.3-8.3 percentage points, results that are consistently significant at the 1-2% level. The high degree of significance despite relatively few questions demonstrates that the improvement that comes due to TA videos are particularly strong.

While the current study has relied heavily on quantitative data, it suggests a wealth of potential future studies to identify the pathways by which the TA test preparation videos may be helping students perform better on exams. The most straight-forward is that it helps students comprehend the content better. Practice problems by themselves are an exceptionally effective teaching tool (Norman & Wills, 2015). Having students practice additional problems after some time has elapsed since the material was taught when coupled with the benefits of the TA system helps them review and recall earlier learning better than only handing out a practice exam or having a review session.

It may be that the student access to the videos is the most important element. While in-person reviews have the advantage that students can ask follow-up questions, the fact is that most students do not. Having short videos allow students to review the professor's explanation multiple times. Current software allows professors to observe how many students watch each video, how many times each video was viewed, and the total amount of time spent on them. In recent semesters, roughly half of the students watch the videos at least once; the average video is watched 1.5 times by each student; some students watch particular portions of a video 5 or more times. While this study has been undergone at a very aggregate level, a more individualized study could identify which students watch which videos the most and attempt to identify clearer causal effects from either number of times viewed or number of minutes spent watching for particular questions. Doing this would also enable instructors to identify particular questions students struggle with or portions of videos that are more engaging and useful than others.

TA videos may reduce test anxiety, which has the potential to mask a true measure of a student's content learning (Gerwing et al., 2015; Hughes, 2005; Stankovska et al., 2018; Tali, 2017). Providing the framework and time to critically evaluate, reflect, and think deeply about the content learned and test format are important contributions the TA video methodology provides in helping students manage test anxiety (Damer & Melendres, 2011; Demir, 2016; Hughes, 2005; Gerwing et al., 2015; Seeley et al., 2018). Seeing someone else go through a similar test with no stress and thorough explanations may give more confidence than simply having practice tests and their answer key. Students may have more reassurance that the format of the test will be similar.

It could also be that humor used in the videos relieves student test-taking anxieties (Berk, 2000; Randler et al., 2016). If lower anxiety is the chief benefit, future research could give students brief surveys on their nervousness before and after watching the videos and again before the test. Two versions of videos could be created, one with humorous asides and one without and a comparison made to see if humor lowers anxiety by more.

Conclusions

The results show that think aloud (TA) videos significantly improved student performance on exams. When TA videos were available, students scored higher on questions they had not directly reviewed by 7.6 percentage points. These findings show that TA videos succeed in several areas. They encourage greater critical thinking, enabling students to generalize from one question the professor demonstrates and explains to additional applications in other questions. They help students master the economics content and feel more confident in their ability to understand the material.

TA as an engagement strategy and intervention has promise. Further research regarding using TA videos in various higher education courses across varied disciplines could prove interesting for comparison. Future research could examine how humor in think aloud videos may add more to our understanding regarding students' perceptions of their learning environments while learning critical, discipline-specific content.

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Declaration of Interest Statement

The authors declare that they have no conflict of interest. Human subject approval was granted by the Tarleton State University Institutional Review Board, IRB No. 2016-051616-16074.

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